ANOMALOUS INNERVATION OF THE HAND MUSCLES

Tom Rowntree, London, England

From the Peripheral Nerve Injury Clinic, Royal National Orthopaedic Hospital

According to the usual text-book descriptions the median nerve supplies the abductor pollicis, opponens pollicis, flexor pollicis brevis and the two lateral lumbricals, while the ulnar nerve supplies all the other muscles in the hand (Gray 1946, Cunningham 1931, Wood Jones 1941). Several articles published since about 1890, notably in the French and the German literature, have mentioned variations found in anatomical dissections. The articles are remarkably contradictory. For example, Spourgitis (1895) stated that ulnar innervation of flexor pollicis brevis was very unusual—he had found it only once in all his dissections; whereas Riche (1897) considered it to be constant. Brooks (1886) drew attention to the existence of two heads of flexor pollicis brevis and found that their nerve supply varied. In dissections of thirty cadavers, flexor pollicis brevis was supplied by the ulnar nerve alone in five and by the median nerve alone in five; in nineteen the superficial head was supplied by the median nerve and the deep head by the ulnar nerve; in one the ulnar nerve supplied all the thenar muscles. Hovelacque reviewed the literature in 1927. He quoted Froment (1847) as stating that the median nerve constantly gave a branch to adductor pollicis; but Frohse and Fränkel (1908) found this in only 10 per cent., a figure with which Poirier (1901) agreed.

The first clinical study of the subject seems to be that by Hight (1943). In twenty patients with median nerve division, flexor pollicis brevis was paralysed in only four; in twenty-five with ulnar division only one showed any wasting of flexor pollicis brevis. The obvious explanation of these figures is dual innervation of this muscle. Hight’s patients were the early ones in the Oxford series and are included in my analysis.

Murphey, Kirklin and Finlayson (1946) examined 698 ulnar nerve lesions, and found that the first dorsal interosseous was innervated by the median nerve in four patients, in one of whom abductor digiti minimi was also supplied by the median. In all four patients the lesion was above the elbow; in two, blocking of the ulnar nerve at the wrist produced paralysis, suggesting an anastomosis from the median to the ulnar nerve in the forearm. In 551 median nerve injuries, opponens pollicis was found innervated by the ulnar nerve once only. These workers used exceptionally strict criteria for the activity of a given muscle, and in their large series there may have been other anomalous innervations which they did not accept.

Clinical material—I have studied the records of all the median and all the ulnar nerve lesions from Mr Seddon’s clinic at both the Wingfield-Morris and the Royal National Orthopaedic Hospitals. There were 688 cases in the group, but many were unsuitable for inclusion in the analysis. The final number accepted was 226, namely 102 median and 124 ulnar nerve injuries. For a case to be accepted there had to be definite evidence of complete interruption of axonal continuity; either the nerve was seen to be divided at operation or, in certain lesions in continuity, direct electrical stimulation of the nerve exposed at operation failed to produce contraction in any muscle. Percutaneous stimulation was used to obtain corroborative but never absolute evidence of the distribution of a nerve. Incomplete lesions and lesions of both nerves were discarded. Throughout the series there has been a high standard of notation, but the statement “ulnar intrinsics paralysed” without any record of more detailed motor examination made it necessary for a few cases to be excluded. The findings in all the accepted cases may be regarded as accurate, for they were made by workers who were fully conversant with the pitfalls of clinical examination of individual muscles and with the trick movements described by Wood Jones (1919). The power of muscles was
assessed according to the Medical Research Council's 0-5 grading (1942). This system is reasonably accurate if there is one observer throughout, but some discrepancies occur, especially between 2 and 3, when assessments have been made by several clinicians. Therefore in this analysis 0 and 1 are classified as paralysed, 2 and 3 as weak, and 4 and 5 as fully active.

Apart from visual and electrical proof of injury to either nerve, additional evidence was obtained in some instances by means of blocking the intact nerve with procaine and then observing the resultant paralysis (Hight 1942). Unfortunately, this was not done in all patients with anomalous innervation owing to pressure of work at the time.

**TABLE I**

<table>
<thead>
<tr>
<th>102 Median Nerve Lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients...</td>
</tr>
<tr>
<td>Abductor brevis...</td>
</tr>
<tr>
<td>Opponens pollicis...</td>
</tr>
<tr>
<td>Flexor brevis...</td>
</tr>
<tr>
<td>Adductor pollicis...</td>
</tr>
</tbody>
</table>

**TABLE II**

<table>
<thead>
<tr>
<th>124 Ulnar Nerve Lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage...</td>
</tr>
<tr>
<td>Number of patients...</td>
</tr>
<tr>
<td>Abductor brevis...</td>
</tr>
<tr>
<td>Opponens pollicis...</td>
</tr>
<tr>
<td>Flexor brevis...</td>
</tr>
<tr>
<td>Adductor pollicis...</td>
</tr>
</tbody>
</table>

Only the median and the ulnar nerves have been considered. There has been no certain evidence of innervation of any thenar muscles by the musculo-cutaneous or the radial nerves (Foerster 1929), although in one or two instances it was just possible. In this series, therefore, if after division of the median nerve a muscle in the hand was fully active, it was considered to be supplied by the ulnar nerve; if active but weak, it was considered to have had a dual innervation; if paralysed, it was of course supplied by the median nerve. No attempt has been made to differentiate between the two heads of flexor pollicis brevis, because clinically it is one muscle. The lumbricals have been ignored owing to the difficulty of testing them accurately.

*Note—In all the figures and tables, colour indicates nerve supply and not voluntary power.*

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Analysis of findings—Tables I and II show the possible combinations of nerve supply. It is seen that the text-book description is the commonest arrangement, abductor pollicis brevis, opponens pollicis and flexor pollicis brevis being supplied by the median nerve and the others by the ulnar nerve. There is an inconsistency in the figures, however, for flexor pollicis brevis remained active in most of the median (73 per cent.) as well as in most of the ulnar injuries (58 per cent.). This, of course, is explained by the fact that flexor pollicis brevis usually has a dual supply and loss of one component may leave its power not appreciably altered.

Figures 1 to 3 show the common arrangements pictorially, with emphasis on the innervation of flexor pollicis brevis. Figure 1 shows the pattern in 29 per cent. of the ulnar lesions and in 38 per cent. of the median lesions, or in 32 per cent. of the whole. Figure 2 shows that there was clinical evidence of dual innervation of flexor pollicis brevis in 15 per cent. of the whole. Figure 3 represents the findings in 32 per cent. of the ulnar lesions and
in 10 per cent. of the median lesions, or in 33 per cent. of the whole. These three groups made 80 per cent. of the total.

It is significant that one-fifth of all the cases studied had an anomalous nerve supply of some kind. On referring back to Tables I and II, it is seen that six cases had an unusual innervation of abductor pollicis brevis alone. Of these six, in one (Table II, last column), we know that the ulnar nerve was responsible, for abductor pollicis brevis was paralysed after division of this nerve. In the other five, all median injuries (Table I, columns 1 and 9), it is not certain why abductor pollicis brevis remained active.

Apart from these cases, there is every gradation from complete ulnar to complete median innervation of the hand. Figure 4 shows one extreme in which all the muscles received ulnar innervation. This occurred in four patients, all with median lesions; to these may be added another three whose only motor loss was weakness of abductor pollicis brevis. Of the seven,

**TABLE III**

**Six Ulnar Nerve Lesions**

<table>
<thead>
<tr>
<th>NAME</th>
<th>LEVEL</th>
<th>DORSAL INTEROSSEI</th>
<th>PALMAR INTEROSSEI</th>
<th>HYPOTHENAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>De J.</td>
<td>ELBOW</td>
<td>1 2 3 4</td>
<td>? ? ?</td>
<td></td>
</tr>
<tr>
<td>D.</td>
<td>ELBOW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H.</td>
<td>WRIST</td>
<td></td>
<td>? ? ?</td>
<td></td>
</tr>
<tr>
<td>J.</td>
<td>WRIST</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R.</td>
<td>ELBOW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T.</td>
<td>ELBOW</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table III. This table gives further details of six cases in which the median supply exceeded that seen in the common patterns of Figures 1, 2 and 3. Five of the cases had the patterns shown in Figures 5 and 6, while the sixth, Case R., had dual innervation of adductor pollicis.

five had wrist-level lesions; in one patient procaine block of the ulnar nerve at the elbow produced complete paralysis of the hand. In these five there can have been no motor branch of the median nerve in the hand, except possibly to abductor pollicis brevis, and in the one just mentioned we know that there was no anastomosis across to the ulnar nerve in the forearm. In the remaining two cases in this group, the lesions were near the elbow and no procaine blocks were performed.

At the other end of the scale we have median innervation of each of the four thumb muscles (Fig. 5), with median innervation of one or more interossei in addition (Fig. 6). There were five such cases, with a sixth in which there was dual innervation of adductor pollicis and of several interossei (Case R).

Table III gives further details of these six cases. It will be seen that only two of the ulnar lesions were at the wrist, the other four being at the elbow. Case D had an injury of
the ulnar nerve at the elbow but no paralysis of the hand muscles. A median block at the elbow produced complete paralysis of the hand. Percutaneous stimulation of the ulnar nerve at the wrist, however, produced strong contraction of all the interossei. This suggested that the motor supply to the interossei travelled as far as the elbow in the median nerve and then crossed over to the ulnar nerve in the forearm. In Case H the converse obtained. This patient had a low ulnar lesion, but electrical stimulation of the ulnar nerve at the elbow produced a good contraction in the hypothenar muscles, the first dorsal interosseous, the adductor pollicis and the palmar interossei, suggesting a free anastomosis from the ulnar to the median nerve in the forearm.

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FIG. 4

The pattern of innervation in 2 per cent. of cases. All the thenar muscles were supplied by the ulnar nerve. See column 1 of Table I.

FIG. 5

The pattern of innervation in 2 per cent. of cases. All the thenar muscles, including adductor pollicis, were supplied by the median nerve. See column 5 of Table II.

FIG. 6

The pattern of innervation in 1 per cent. of cases. All thenar muscles, including adductor pollicis, and the first dorsal interosseous were supplied by the median nerve. See column 1 of Table III, Cases de J. and D.
CONCLUSIONS

1. Voluntary activity of any given muscle in the hand is not an absolute indication of the state of the nerve which usually supplies it.
2. Significant variations in the standard pattern of innervation have been found in 20 per cent of 226 cases studied.
3. The pattern of innervation described in standard text-books occurred in only 33 per cent of cases.
4. A striking variation is the supply of every thenar muscle by the ulnar nerve. In other cases the first dorsal interosseous muscle may be supplied by the median nerve.
5. In order to arrive at an accurate diagnosis when anomalous innervation is suspected, nerve blocks at appropriate levels are required.
6. Great care must be taken during operations to avoid damage to connections between the ulnar and the median nerves, especially in patients with anomalous innervation of the hand muscles.

I wish to pay tribute to all members, past and present, of the Peripheral Nerve Injury Units who have so accurately recorded their findings in the cases used in this analysis. I thank Mr H. J. Seddon for all his help and encouragement, and Miss Stanley for the drawings.

REFERENCES

Froment (1847): Quoted by Hovelacque, below.
Medical Research Council (1942): War Memorandum No. 7. Aids to the Investigation of Peripheral Nerve Injuries.